

Achieving the Joint Vision: The Role of Operational Context in Future Systems

By

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Abstract

The US Joint Vision demands automation that can improve tactical and operational processes. Operational context is the sum of battlespace operational planning and execution knowledge, information and data, plus the real-time tactical picture. Effectively sharing operational context is key to achieving more intelligent automation and support for command decision-making.

The net-centric exchange of operational context, requires a shared top-down information reference model to ensure consistency of content and meaning, without which there is no shared understanding. Properly chosen, a reference model can conceptually link all elements of the battlespace and provide a framework for sophisticated automated reasoning and effective Joint and Coalition communications.

Thus, there is a critical relationship between automation, operational context, and interoperability. Future C3I, Combat Systems, and autonomous systems must evolve to create, communicate and process operational context. This paper will report on work being conducted under the C4I Coalition Warfare ACTD to make this a reality.

SHARED OPERATIONAL CONTEXT:

Evolving and revolutionary United States military operational concepts characterized in the US Joint Vision leverage improving communications and computer capabilities to automate and integrate all aspects of Joint and Coalition theater operations. Largely technology enabled, the resulting revolution in military affairs (RMA) is establishing high capability expectations for future networked command and control (C²), tactical and sensor systems. Specifically, in the aggregate these systems and processes are expected to lead to dominance of the battlespace in part through information superiority for allied forces. Information superiority in turn is derived when relevant and accurate information can be provided in a timely manner¹.

With network connectivity will come the opportunity to establish information superiority through more automated and efficient processes in the areas of planning, execution, monitoring, and decision support. We know that this will be a challenge at many levels because within a Joint or Coalition operation there are always interoperability challenges, beyond technical, that reflect cultural, linguistic, doctrinal, operational, tactical, procedural and equipment differences. Timely information collection, processing, compilation, presentation, and dissemination are required to support effective command decision-making at

¹ Information/Knowledge Advantage. Information Superiority elements: Accuracy, Timeliness, Relevance. We need a force which is designed and capable of fighting first for information superiority. [ref: <http://www.nwc.navy.mil/pres/presentations.htm> Select 'NCW Symposium 14 Aug 01.ppt' Cebrowski, Slide 19]

all echelons. Further, we expect these processes will rely on improved person-to-person collaboration tools in addition to expanded adaptive automated workflow processes that span a global information grid (GIG)². The classic objective of providing the decision-maker with the right information, in the right format, at the right time is still objective vision. To achieve this vision we will need pervasive automation applied to the widest range of tactical and operational information processing.

A shared Common Tactical Picture³ (CTP) is perhaps the most recognized embodiment of information superiority. The CTP is a tool to develop and maintain situational awareness. All users share a common underlying tactical data set and the CTP is tailored as required at each echelon and type of command.⁴ Additionally, there is a broad range of real-time coordination and collaboration activity being seen on Internet chat-type channels during net-centric warfare (NCW) experimentation⁵. This communication capability provides extended situational awareness beyond the predominantly sensor-derived CTP.

A well-trained naval officer provided with only the CTP does not have information superiority! He/she must be able to reason about the CTP with an understanding of other mission essential context information. The Common Operational Picture⁶ (COP), many elements of which are typically included in Operations Plan/Orders/Tasking (OPPLAN/OPORD/OPTASK) messages, provides the commander with “operational context,” information such as:

- the scope of operations,
- missions,
- commander's intent,
- rules of engagement (ROE) ,
- command relationships,
- task force order of battle,
- courses of action
- tasking,

² If you are not interoperable, you are . . . Not on the net, Not contributing, Not benefiting. Not part of the information age [ref: <http://www.nwc.navy.mil/pres/presentations.htm> Select ‘NCW Symposium 14 Aug 01.ppt’ Cebrowski, Slide 17]

³ Common Tactical Picture (CTP). The CTP is derived from the Common Tactical Database (CTD) and other sources. It refers to the current depiction of the battlespace for a single operation within a CINC’s AOR including current, anticipated or projected, and planned disposition of hostile, neutral, and friendly forces as they pertain to US and multinational operations ranging from peacetime through crisis and war. The CTP includes force location, real time and non-real time sensor information, and amplifying information such as METOC, SORTS, and JOPES. (CJCSI 3151.01, p. GL-3, GL-4)

⁴ Extending the Littoral Battlespace Advanced Concept Technology Demonstration, Proceedings of Common Tactical Picture Workshop One, 8-9 July 1998, pg. 5.

⁵ Internet chat is being used heavily in operational concept experimentation being conducted by Navy Warfare Development Command.

⁶ Common Operational Picture (COP). The COP is the integrated capability to receive, correlate, and display a Common Tactical Picture (CTP), including planning applications and theater-generated overlays/projections (i.e., Meteorological and Oceanographic (METOC), battle plans, force position projections). Overlays and projections may include location of friendly, hostile, and neutral units, assets, and reference points. The COP may include information relevant to the tactical and strategic level of command. This includes, but is not limited to, any geographically oriented data, planning data from JOPES, readiness data from SORTS, intelligence (including imagery overlays), reconnaissance data from the Global Reconnaissance System (GRIS), weather from METOC, predictions of nuclear, biological, and chemical (NBC) fallout, and Air Tasking Order (ATO) data. (CJCSI 3151.01, p. GL-3)

- coordination guidelines,
- schedule of operations,
- communication plans,
- battlespace management (e.g., waterspace management),
- sensor management plans,
- threat assessment, and
- environmental forecasts and prediction guidance.

Today, people are the autonomous intelligent collaborating elements in the C² process. They are aware of the maritime operational context and use this knowledge to process and prioritize their action and interaction. Use of automation as a key enabler of the CTP/COP is widely expected.⁷ In the future our automated systems [applications, agents, and autonomous systems - A³S] must also understand and use a broad scope of maritime operational context. This will enable them to reason with more precision, about relevant matters, and provide timely smarter recommendations and skilled assistance. In this new paradigm, shared operational context is available on the GIG to all and A³S are both data driven and context driven, see figure 1.

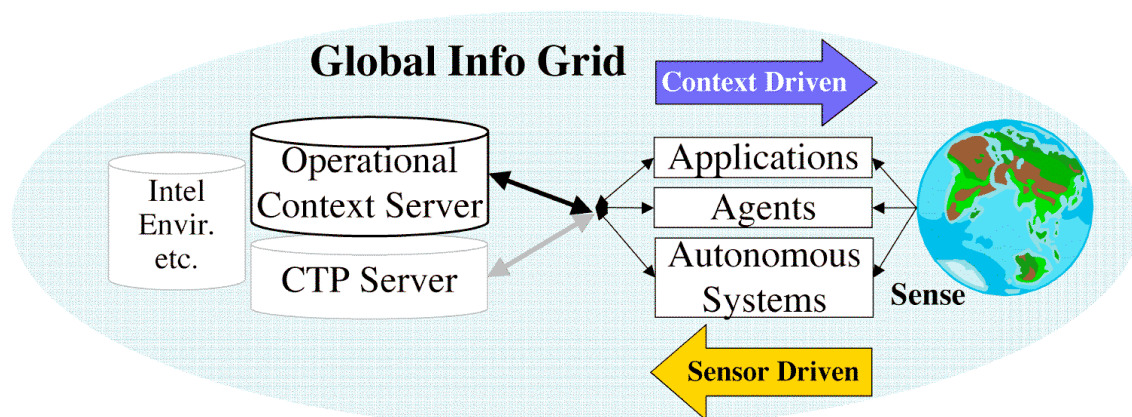


Figure 1: Sensor and Context Driven

PRACTICAL CONSIDERATIONS:

If in fact operational context is important to future automated systems and achieving the Joint Vision then we must ask some practical questions regarding its definition, creation, and distribution. If processing and process automation are expected to become ubiquitous, or at the very least widespread, then all/most A³S will need to have access to both relatively static and dynamic operational context. This in turn raises two important issues, how is it defined and created?

If each A³S defines operational context for itself then there is no guarantee that context generated by one A³S can be understood and used by another, translation can be shown to not always work. Further, we must not overly burden the operator and commander with many new data entry tasks. Rather, it would be preferred to define operational context in manner similar to today's hierarchical pass-down planning process. Each commander adds

⁷ Extending the Littoral Battlespace Advanced Concept Technology Demonstration, Proceedings of Common Tactical Picture Workshop One, 8-9 July 1998, pg. 5.

detail to the overall plan and passes it down. This implies a shared definition for operational context and a structure that supports levels of abstraction/detail. Such a shared top-down information reference model would ensure consistency of content and meaning, without which there is no shared understanding. Properly chosen, a reference model should conceptually link all elements of the battlespace to provide a framework that supports sophisticated automated reasoning. This shared reference model approach would also eliminate direct system-to-system message translations [an Order N^2 problem] in favor of a common model interconnect scheme [at worst an Order N problem]⁸. The reference model should be appropriate for the Joint and Coalition tactical and operational domain. It should also be very generic and not show a country, service, application, community, or technology bias that might limit its acceptance or utility.

As desirable as the shared model approach might be it is worth mentioning that other approaches are possible and that they also have merit, but might not be ideal. Some technical approaches assume heterogeneity as the only realistic implementation model. Such an approach is necessary when there is limited control of information sources or A³S design, but will likely suffer from too much manual data entry and inconsistent context representation across the GIG. The trade is that it could provide a more expedient but limited method of applying/developing operational context capabilities in A³S.

When faced with the problems of shared understanding and interoperability NATO established a working group to define a common data interchange specification, called Land Command and Control Information Exchange Model (LC2IEDM). The current version, known as Generic Hub version 4 (GH4) is a proposed STANAG. This reference model has the desired characteristics cited above, namely that it:

- Describes a broad range of battlespace information useful for planning, execution, reporting, and monitoring (COP and CTP)
- Represents the domain information as both information entities and associated relationships to other information items. This meta-information creates comprehensive relational data structures that capture the breadth of operations, courses of action, abstraction, etc.
- Is very generic, as well as Joint and Coalition by design
- Supports hierarchical /level-of-detail definition of context
- Can be directly instantiated as a relational data base
- Has been used by over a half dozen NATO countries as reference model for national C² systems that have been demonstrated to be interoperable
- Is suitable for maritime operational context expression with minimal improvements
- Has provided a baseline ontology for a shared operational context (this was its original and achieve objective)
- Can serve as a reference model for eXtensible Mark-up Language (XML) schema definition efforts (a top-down definition approach to ensure shared understanding)
- Does not place implementation restrictions on developers

A high-level view of the GH4 reference model is provided in figure 2. The Object Type – Object Item relationship is classic Class – Instance, but the model is not object oriented, rather it is fundamentally relational. The Object Type – Object Item relationship enables planning at

⁸ In the longer-term, all systems might evolve to directly employ a common reference model eliminating the need for translation.

the abstract level [you can develop a plan that requires an attack class submarine without needing to specify which submarine until later when the details of the plan are being added]. Table 1 shows the five key entities used in the model and their roles⁹.

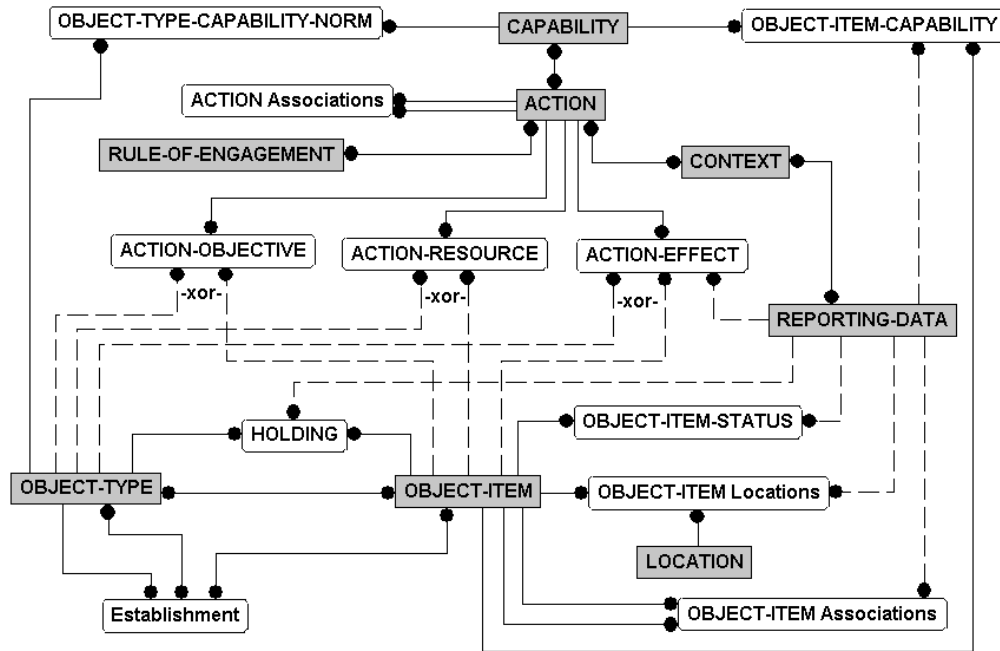


Figure 2: High-Level view of the GH4 Model

Table 1. GH4 Five Key Entities and Their Roles

Key Entity	Entity Definition	Information Category
OBJECT-ITEM ¹⁰	An individually identified object that has military significance. Examples are a specific person, a specific item of materiel, a specific geographic feature, a specific co-ordination measure, or a specific unit.	Contents (Who and What)
OBJECT-TYPE	An individually identified class of objects that has military significance. Examples are a type of person (e.g., by rank), a type of materiel (e.g., self-propelled howitzer), a type of facility (e.g., airfield), a type of feature (e.g., restricted fire area), or a type of organisation (e.g., armoured division).	
CAPABILITY	The potential ability to do work, perform a function or mission, achieve an objective, or provide a service.	
LOCATION	A specification of position and geometry with respect to a specified frame of reference. Examples are point, sequence of points, polygonal line, circle, rectangle, ellipse, fan area, polygonal area, sphere, block of space, and cone. LOCATION specifies both location and dimensionality.	Positioning and Shapes (Where)
ACTION	An activity, or the occurrence of an activity, that may utilise resources and may be focused against an objective. Examples are operation order, operation plan, movement order, movement plan, fire order, fire plan, fire mission, close air support mission, logistics request, event (e.g., incoming unknown aircraft), or incident (e.g., enemy attack).	Dynamics (How)

APPLYING CONTEXT TO ACHIEVE THE JOINT VISION:

⁹ NATO, Land Command and Control Information Exchange Model (LC2IEDM), ADatP-32, edition 2.0, 31 March 2000

¹⁰ The convention is to annotate the names of entities in capital letters. If the name of an entity is used in plural, then a lower-case "s" is appended to the name without changing the name to conform to standard English usage, (e.g., the plural of CAPABILITY is written CAPABILITYs).

We began by discussing the need for automation in order to achieve the Joint Vision. This was followed by the claim that A³S need to be both data and context driven. And finally we discussed how context might be represented and how a practical top-down specification can be based on the GH4 model. Thus, there is a critical relationship between automation, operational context, and interoperability. GH4-specified operational context can serve as a rich, comprehensive framework enabling information superiority.

Under the C4I Coalition Warfare ACTD the GH4 model is being applied to a maritime context. An assessment of its fit with maritime operations is being made. A Coalition Data Server, instantiated from the GH4 model, is being interfaced with a submarine combat control system's CORBA tactical data server by a team at the Naval Undersea Warfare Center¹¹. This will enable an initial submarine/maritime assessment and demonstration of the model as a real-time CTP server. Team members from the Institute for Defense Analysis¹² have developed an XML schema from the GH4 reference model. Team Members from the Naval Postgraduate School¹³ are working on 3D Virtual Reality Modeling Language (VRML) visualization techniques for representing various dynamic operational context information elements represented in the GH4 model. Each of these coupled efforts relies on the structured comprehensive nature of the GH4 model and the ability to process it in automated ways. This effort is demonstrating what the team believes to be capabilities and methods that will enable a fundamentally new level of A³S functional and process automation. These enabling capabilities are necessary to reach the Joint Vision for military operations.



Erik Chaum is a member of the Combat Systems Department at NUWC Division Newport, where he works on a wide range of advanced concepts. He serves as a Naval Sea Systems Command (NAVSEA) representative in the Systems Command Liaison Office at the Office of Naval Research (ONR) and is the U.S. National Leader of The Technical Cooperation Program (TTCP), Maritime Systems Group, Technical Panel One. He has lead NUWC's recent virtual submarine participation in Fleet Battle Experiments Golf and India. He is a graduate of the U.S. Naval Academy (1977) and the Management of Technology program at the Massachusetts Institute of Technology (1984).

¹¹ Lead by Mr. Fred Burkley with assistance from Mr. Roger Howlett, and Mr. Gerard Poirier

¹² Dr. Eugene Simaitis, and Dr. Francisco Loaiza

¹³ Dr. Don Brutzman, CAPT Shane Nicklaus, USMC, Doug Horner, CAPT Mike Hunsberger, USAF